The Arrangement of the Micro-crystals in the Graphite Flakes Segregated from Solidifying Pig Iron

By

Shin-ichi Shimadzu

(Received April 6, 1933)

Abstract

The arrangement of the micro-crystals in the graphite flakes produced by being segregated from solidifying pig iron at the Kenjiho Steel Works in Korea was examined, in the present experiment, by taking their Laue-photographs; and it was observed that the micro-crystals in the graphite flakes had a tendency to arrange themselves in a fibrous manner with the crystallographic axis $[11\bar{2}0]$ as the fibrous axis in the direction parallel to the flat surface of the flake.

The form of the crystal of graphite is hexagonal holohedry, and the dimensions of its unit cell have been determined by Hassel and Mark[1], and Bernal[2] as given in the following table.

Table

	side a in Å	side c in Å	axial ratio c/a
Hassel & Mark	2.46	6.79	2.76
Bernal	2.45	6.82	2.77

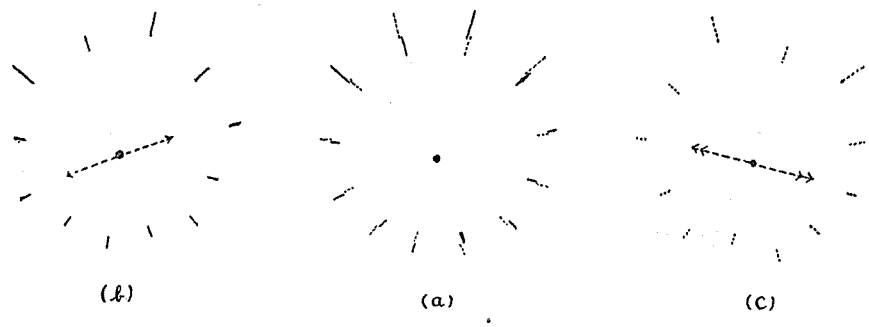
The specimen, about 2 mm. in diameter and 0.01 mm. or less in thickness, was illuminated by a narrow pencil of tungsten radiation nearly perpendicularly to its flake surface, and the Laue-photograph was taken on a photographic plate placed perpendicularly to the direct

1. Z. Physik **25**, 317 (1924).
2. Proc. Roy. Soc. (London) 106 A, 749 (1924).

beam of the X-rays. The photograph shown in Fig. 1 in the Plate was obtained in the above way. In this photograph we can detect clearly twelve radiating bands, and by closer examination we can detect that every band is composed of two parts, internal and external; and that an intense spot appears on every internal band. These radiating bands show the presence of a fibrous arrangement among the micro-crystals. Then, by the aid of the crystallographic globe[1], the fibrous axis and the range of the rotation angle of the micro-crystals around the fibrous axis were determined, and the following results were obtained.

The specimen is composed of two groups of micro-crystals, corresponding to the two parts of the radiating bands. These two parts of the radiating bands are distinguished by the full and the dotted lines in (*a*) of Fig. 1, which is a sketch of Fig. 1 in the Plate, and (*b*) and (*c*) in Fig. 1 represent these two parts separately. The micro-crystals of each group rotate around the fibrous axis $[11\bar{2}0]$ within the angular

Fig. 1



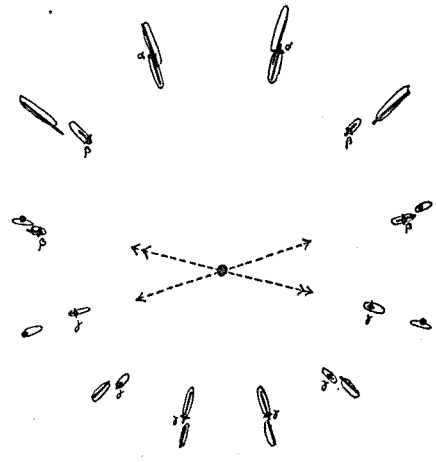
range of about 3° respectively. The angle between the fibrous axes of the two groups of the micro-crystals is about 30°, and these two fibrous axes lie nearly in the flake surface. The directions parallel to these fibrous axes on the photographic plate are shown by the arrows in Fig. 1 in the Plate, and also in (*b*) and (*c*) in Fig. 1. The internal radiating bands in Fig. 1 in the Plate are due to the family of the plane $(01\bar{1}1)$, and the external ones are due to the family of the plane $(11\bar{2}2)$. The intense spots on the internal bands are the spectra of the α, β or γ line of the L series of tungsten due to the reflection from the atomic planes $(01\bar{1}1)$.

1. U. Yoshida: Japanese J. Phys., **4**, 133 (1927)
   S. Takeyama: These Memoirs, **12**, 257 (1929)

The same graphite flake was again examined with the X-rays from a copper target. The Laue-photograph taken in the same way as before is reproduced in Fig. 2 in the Plate. In this photograph twelve radiating bands appear as before. One half of them contain the intense spots, which are nothing but the spectra of the α and β lines of the K series of copper, due to the reflection from the atomic planes $(01\bar{1}1)$. The other half of the above radiating bands are composed of two parts, i. e. internal and external parts, as seen in Fig. 1 in the Plate. The examination of these radiating bands by the crystallographic globe gave the same conclusion as in the case of Fig. 1 in the Plate, as regards the arrangement of the micro-crystals. The directions parallel to the fibrous axes on the photographic plate are shown by the arrows in Fig. 2 in the Plate.

The coincidence between the photographic pattern and the calculation is shown diagrammatically in Fig. 2. In this figure the thick lines show the calculated positions and the lengths of the radiating bands, the closed curves which cover the thick lines indicate the positions of the radiating bands actually appearing in Fig. 1 in the Plate, and the dots on the internal thick lines represent the calculated and observed positions of the spectra of the α, β or γ line of the L series of tungsten, due to the reflection from the atomic planes $(01\bar{1}1)$. Here it must be noted that the photographic pattern in Fig. 1 of the Plate is not exactly symmetrical in reference to the horizontal line passing through the central spot. As this seemed to the writer to be caused by the fact that the surface normal of the graphite flake was inclined a little to the direction of the beam of the X-rays, he calculated the position of the radiating bands shown in Fig. 2, by taking this inclination as $2^{\circ}\frac{1}{2}$. The correctness of this consideration was justified by the good coincidence between the observed and the calculated positions of the radiating bands as is shown in Fig. 2.

Fig. 2



Many other samples were also examined similarly, and it was observed that some of them were composed of two sets of micro-crystals with the fibrous arrangement, each of which had the crystallographic axis $[11\bar{2}0]$ as its fibrous axis in the flake surface, the angle between the two fibrous axes being different in each case; and that the others were composed of several sets of micro-crystals with a similar fibrous arrangement.

Thus it may be concluded that the micro-crystals in graphite flakes have a tendency to arrange themselves in a fibrous manner, with the crystallographic axis $[11\bar{2}0]$ as the fibrous axis in the direction parallel to the flat surface of the flake.

In conclusion, the writer wishes to express his sincere thanks to Prof. U. Yoshida and Mr. K. Tanaka for their kind guidance and suggestions, and also to Prof. A. Matsubara for his kind advice and for his contribution of graphite flakes, which he obtained at the Kenjiho Steel Works in Korea.

Plate

Fig. 1

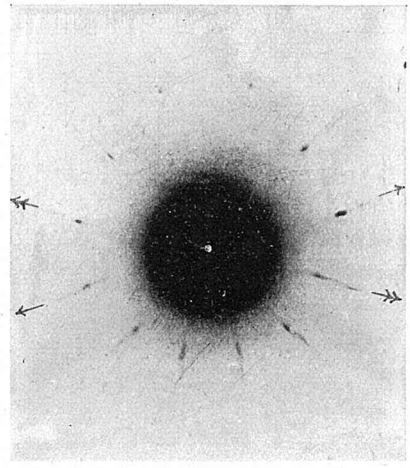


Fig. 2